CLAIMS

1.   An X-ray inspection system which incorporates a detector
which relies on the electro-magnetic cascade effect produced
in suitable materials when bombarded with X-rays so that energy
is transferred into the material at different depths depending
on the energy of incident X-rays, wherein the first component
on which the X-rays impinge comprises a relatively thin crystal
and unwanted background noise is reduced by placing a vessel
containing a fluid whose density is less than that of air, in
front of the detector crystal array.

2.   An X-ray inspection system as claimed in claim 1, wherein
the vessel comprises a bag, formed from film transparent to X-
rays.

3.   An X-ray inspection system as claimed in claim 1 or 2,
wherein the fluid is helium.

4.   An X-ray inspection system as claimed in any of claims 1
to 3, in which the fluid is maintained at atmospheric or
slightly greater than atmospheric pressure.

5.   An X-ray inspection system in which a thin X-ray absorber
is placed upstream of an object under investigation so as to
remove low energy X-rays.

6.   An X-ray inspection system as claimed in claim 5, wherein
the absorber removes X-rays below 0.5MeV.

7.   An X-ray inspection system as claimed in claim 5 or 6,
wherein the absorber is a sheet of lead 10mm thick.

8.   An X-ray inspection system as claimed in any of claims 1
to 7, wherein the background is reduced by applying a magnetic
field in the region in front of a detector crystal array so as

to sweep away electrons from that region.

9.   An X-ray inspection system for determining the material composition of an object wherein the detector includes a crystal, and a magnetic field is generated in front of the crystal between the object and the crystal, to deflect stray electrons from the crystal.

10.   A material discrimination detector of the type described in EP 0621959 in combination with either or both of a vessel containing low density fluid and means for generating a magnetic field, in front of the detector.

11.   An X-ray material inspection system of the type described in EP 0621959, wherein electrons and scattered X-rays are removed by positioning at least one collimator in front of the crystal detector.

12.   An X-ray material inspection system as claimed in claim 11, wherein a lead collimator is employed.

13.   A material discrimination system in which the first detector component is a thin scintillation crystal which is required to register an amount of energy deposited by an X-ray that is essentially independent of the X-ray MeV energy, wherein a low Z converter is located after this crystal to stop electrons produced by X-ray interactions downstream of the crystal from being significantly back scattered into the front crystal and prevent electrons leaving the front crystal from returning and depositing more energy in the front crystal, and wherein the low-Z converter is situated between the thin front scintillation crystal and a thicker downstream scintillation crystal, and is adapted to reduce the back scatter of electrons into the front crystal and to prevent electrons which have left the front crystal from returning thereto.

14.   A material discrimination system in which a low-Z

converter is located downstream of a first scintillating
crystal detector to prevent electrons produced by X-ray
interactions downstream of the said first crystal from back
scattering into the first crystal and to prevent electrons from
leaving the first crystal and returning thereto, and wherein
the low-Z converter is situated between the thin front
scintillation crystal and a thicker downstream scintillation
crystal, and is adapted to reduce the back scatter of electrons
into the front crystal and to prevent electrons which have left
the front crystal from returning thereto.

15.   A material discrimination system as claimed in claim 13
or 14, wherein the low Z converter is aluminium.

16.   A material discrimination system as claimed in claim 14
or 15, wherein behind the low-Z converter is located a high-Z,
high density convertor, whose main purpose is to ensure that
even the higher MeV energy components of an X-ray beam lose
energy at the maximum rate so that the electro-magnetic cascade
reaches equilibrium, to ensure that the maximum amount of
energy per X-ray is deposited in the following crystal, so that
it will respond preferentially to higher energy X-rays.

17.   A material discrimination system as claimed in claim 16,
where the high-Z material is tungsten.

18.   A material discrimination system as claimed in claim 16
or 17, wherein electrons travelling backwards out of the said
crystal as a result of multiple Coulomb scatter, are absorbed
in both the low and high-Z converters so that they are unable
to reach the thin front crystal.

19.   A material discrimination system as claimed in claim 18,
wherein high-Z, high density converters, are interleaved with
scintillating crystals.

20.   A material discrimination system as claimed in claim 19,

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wherein each crystal is read out by a pair of photodiodes or pair of fibres.

21. A material discrimination system as claimed in claim 20, wherein signals from all such pairs of read out devices are added which increases the effective energy of the high energy X-ray component that is registered, and hence the magnitude of the material discrimination effect.

22. A material discrimination system as claimed in claim 19, 20 or 21, wherein an absorber is located at the rear of the detector assembly, to stop electrons produced by X-rays which carry on downstream and scatter in any structure to the rear of the apparatus, from reaching the rear crystal of the detector array.

23. A material discrimination system as claimed in claim 22, wherein the absorber is aluminium.

24. A material discrimination detector of the type described in European patent 0621959 in which the thin front crystal is read out from each side as by a photodiode, or fibre, and the outputs from the two opposite sides of the crystal are added, so as to prevent any left/right asymmetry in signal which can result from reading out at one end only, with respect to direction of motion of the object under investigation relative to the detector.

25. An X-ray inspection/material discrimination system detector comprising a front thin crystal and a rear thick crystal, wherein the latter is read out by a plurality of photodiodes or fibres or other devices which sample at different depths in the beam direction, and the signals from the different sampling devices are added to represent the high energy X-ray component.

26. A detector as claimed in claim 25, wherein outputs from

the two sides of the crystal are combined to prevent left/right asymmetry.

27.   A detector as claimed in either of claims 25 or 26, wherein the second crystal is replaced by an alternating sandwich of crystals and high-Z convertors and each of the crystals in the sandwich is read out using two or more read-out devices.

28.   A detector as claimed in claim 27, wherein the outputs from opposite sides are combined to prevent left/right asymmetry.

29.   A detector as claimed in claim 28, wherein the crystals are read by fibres leading to CCD cameras or photodiodes and all of the read-outs are combined to produce a signal corresponding to the high energy X-ray component.

30.   A material discrimination detector for use in an X-ray discrimination system of the type described in European patent 0621959 wherein the front and rear scintillation crystals are cut from the same ingot of material in order to provide matched performance.

31.   A detector as claimed in claim 30, wherein the material is CsI and the choice of material is such as to minimise persistence of the signal due to low phosphorescence decay.

32.   A material discrimination system of the type described in European patent 0621959 which includes a Linac, and wherein the read-out system is synchronised to the Linac pulse, with one read-out cycle for each pulse, and in which the read-out system also samples the output from crystals between each Linac pulse, so as to provide signals indicative of noise and crystal persistence.

33.   A system as claimed in claim 32 wherein the Linac is

triggered on each alternate pulse only, and during non-beam read-outs, signals corresponding to background, noise and crystal persistence, are subtracted.

34.   A system as claimed in claim 32 or 33 wherein the Linac RF functions in the untriggered condition throughout.

35.   A material discrimination system of the type described in European patent 0621959 which incorporates a Linac in which the channels are normalised so as to overcome non-linear effects due to saturation, and calibration is performed by increasing the X-ray beam flux by known increments.

36.   A system as claimed in claim 35, wherein calibration is performed using a step wedge of absorbing material with increments of thickness chosen to yield fixed decrements of transmission between 90% and 10% when used with a particular Linac.

37.   A method of calibrating a system as claimed in claim 36, involving moving the step wedge across the X-ray beam and determining the average signal value vs. step thickness, for use as a base level for channel to channel normalisation.

38.   A system as claimed in claim 36 or method as claimed in claim 37, wherein the step wedge is formed from PTFE.

39.   A method of material discrimination using X-rays which is performed by generating calibration curves of material discrimination effect (MD) verses transmission T, where T is 1 for zero absorbtion and 0 for completely absorbing objects, and the MD effect is derived from the lower and high energy signals, and calibration is performed using step wedges of suitable absorbing material.

40.   A method of claim 39, wherein a range of curves for calibration is produced using different materials such as PTFE,

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aluminium, and iron, whereby the effective Z of an unknown material can then found by comparing its MD effect and T value with the corresponding values of known materials, and then interpolating.

41. Apparatus as claimed in any of the preceding claims when used for medical and non-destructive testing purposes.

42. Apparatus as claimed in any of the preceding claims when used to perform radio therapy, in which X-ray energies in the range 18 to 25 MeV are employed.

43. A method of testing for the presence of a material whose effective Z is different depending on whether high or low energy X-rays are employed, comprising the steps of inspecting an object under test using high energy X-rays and noting the effective Z of the constituents of the object, inspecting it using low energy Z-rays and noting the effective Z of its constituents, and comparing the values of Z obtained from the two tests for the each identified constituent in the object, and using a look-up table of Z ratios for the two X-ray energies, to assist in determining the identity of each constituent.